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IS 13573-1 (2011): Cable Accessories for Extruded Power Cables, Part 1: for Working Voltages for 1.1 kV upto and Including 3.3kV(E) - Test Methods and Test Requirements [ETD 9: Power Cables]

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# एक्सट्रूडेड पावर केबल के लिए केबल सहायकांग — विशिष्टि

## भाग 1 1.1 कि.वा. और 3.3 कि.वा. (ई) तक की रेटित वोल्टेज — परीक्षण अपेक्षाएँ और परीक्षण पद्धतियाँ

*( पहला पुनरीक्षण )*

*Indian Standard*

# CABLE ACCESSORIES FOR EXTRUDED POWER CABLES — SPECIFICATION

## PART 1 FOR WORKING VOLTAGES FROM 1.1 kV UP TO AND INCLUDING 3.3 kV(E) — TEST METHODS AND TEST REQUIREMENTS

*( First Revision )*

ICS 29.060.20 ; 29.120.99

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NEW DELHI 110002

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Power Cables Sectional Committee, ETD 09

## FOREWORD

This Indian Standard (Part 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Power Cables Sectional Committee had been approved by the Electrotechnical Division Council.

There was no Indian Standard for cable accessories for cable with rated voltage less than 3.3 kV (E). This standard details the performance requirements and the test methods for type tests for cable accessories for use on cables of rated voltage from 1.1 kV to 3.3 kV(E).

There are different methods followed for joints and terminations and the basic technique depends on the voltage rating of the power cable for which the accessories needs to be installed.

This standard was originally published as IS 13573 : 1992 'Joints and terminations of polymeric cables for working voltages from 6.6 kV up to and including 33 kV — Performance requirements and type tests'. This revision has been undertaken to bring it in line with International practices. It has been split up into three parts. The other parts in the series are:

Part 2 For working voltages from 3.3 kV(UE) up to and including 33 kV(E) — Test requirements

Part 3 For working voltages from 3.3 kV(UE) up to and including 33 kV(E) — Test methods

In the formulation of this standard assistance has been derived from the British Standard BS EN 50393 : 2006 'Test methods and requirements for accessories for use on distribution cables of rated voltage 0.6/1.0 (1.2) kV'.

This standard does not cover performance requirements of cable accessories for paper insulated power cables and transition joints.

The joints and terminations of power cables are normally made at site. For practical reasons, this standard is confined to type tests only. For tests at site, reference may be made to IS 1255 : 1983 'Code of practice for installation and maintenance of power cables up to and including 33 kV rating (*third revision*)'.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.The number of significant places retained in the rounded off value should be the same as that of the specified as that of the specified value in this standard.

# *Indian Standard*

# CABLE ACCESSORIES FOR EXTRUDED POWER CABLES — SPECIFICATION

## PART 1 FOR WORKING VOLTAGES FROM 1.1 kV UP TO AND INCLUDING 3.3 kV(E) — TEST METHODS AND TEST REQUIREMENTS

## *( First Revision )*

### 1 SCOPE

This standard (Part 1) details the performance requirements and the test methods for type tests for cable accessories for use on cables of rated voltage from 1.1 kV to 3.3 kV(E). Once the accessories have been successfully type tested, then these tests need not be repeated unless changes are made in the cable accessory materials, design or manufacturing process which might affect the performance characteristics.

Joints, indoor and outdoor terminations for extruded solid dielectric insulated cables are included.

The service operating conditions of accessories shall be compatible with the service operating conditions of the cable.

### 2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

| *IS No.* | *Title* |
|---|---|
| 1554 (Part 1) : 1988 | PVC insulated (heavy duty) electric cables: Part 1 For working voltages up to and including 1 100 V |
| 2071 (Part 1) : 1993 / IEC 60-1 1989 | High voltage test techniques: Part 1 General definitions and test requirements |
| 7098 (Part 1) : 1988 | Specification for cross linked polyethylene insulated PVC sheathed cable: Part 1 For working voltages up to and including 1 100 V |
| 8130 : 1984 | Conductors for insulated electric cables and flexible cords |
| 8308 : 1993 | Compression type tubular in-line connectors for aluminium conductors of insulated cables |
| 8309 : 1993 | Compression type tubular terminal ends for aluminium conductors of insulated cables |
| 8337 : 1976 | Performance requirements of compression joints of aluminium conductors in insulated cables |
| 9968 (Part 1) : 1988 | Elastomer insulated cables: Part 1 For working voltages up to and including 1 100 V |
| 14255 : 1995 | Aerial bunched cables for working voltages up to and including 1 100 volts — Specification |

### 3 TERMINOLOGY

For the purpose of this standard, the following terms and definitions shall apply.

**3.1 Joint** — Accessory suitable for use in air or underground which makes a connection between two or more insulated power cables to form a continuous circuit.

**3.1.1** *Type I Joint* **—** Joint where impact withstand, impulse voltage withstand and metallic screen short circuit current withstand tests are not required.

**3.1.2** *Type II Joint* **—** Joint tested for impact withstand but not for impulse voltage withstand or metallic screen short-circuit current withstand.

**3.1.4** *Type III Joint* — Joint tested for impulse voltage withstand and metallic screen short-circuit current withstand but not for impact withstand.

**3.2 Rigid Joint**

a) Joint which incorporates a resin encapsulant capable of being poured or injected at ambient temperature and which cures to a solid state by an irreversible chemical reaction without the application of external heat.

or

b) Joint which incorporates a non-setting encapsulant within a rigid housing.

**3.3 Non-rigid Joint** — Joint which incorporates polymeric tapes, heat or cold-shrinkable components or pre-moulded parts without a rigid housing.

### 3.4 Type of Joints

a) *Straight joint* — Accessory making a connection between two cables of similar insulation to form a continuous circuit.
b) *Transition joint* — Accessory making a connection between cables having extruded solid dielectric insulation and impregnated paper insulation.

**3.5 Stop End** — Accessory providing a means of insulating an energized cable end.

**3.5.1** *Type I Stop End* — Stop end tested for impact withstand but not for impulse voltage withstand.

**3.5.2** *Type II Stop End* — Stop end tested for impulse voltage withstand but not for impact withstand.

**3.6 Cable Crutch** — Position at which the laid up cores of a multi core cable separate into individual cores.

**3.7 Outdoor Termination** — Termination intended for use where it is directly exposed to either solar radiation or weathering or both.

**3.7.1** *Type I Termination* — Termination where impulse voltage withstand is not required.

**3.7.2** *Type II Termination* — Termination tested for impulse voltage withstand.

**3.8 Type Tests** — Tests required before supplying a type of cable accessory covered by this Indian Standard, on a general commercial basis, in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been successfully made, they need not be repeated unless changes are made in the cable accessory materials, design or type of manufacturing process which might change the performance characteristics.

## 4 COMPONENTS

### 4.1 Connectors

Connectors used within the accessory shall comply with IS 8308, IS 8309 where applicable, or with another relevant Indian Standard.

**4.1.1** Connectors (lugs and ferrules) used should be in line with IS 8337.

### 4.2 Materials

Component material characterization is not a pre-requirement for compliance with this standard.

## 5 ELECTRICAL CHARACTERISTICS

### 5.1 Rated Voltage

The rated voltage of the joints, stop ends and outdoor terminations shall be $U_o/U$ ($U_m$) = 0.635/1.1(1.2) kV and 1.9/3.3 (3.6) kV where,

a) $U_o$ rated power frequency voltage between phase conductor and earth or metallic screen for which the cable accessory is designed;
b) $U$ rated power frequency voltage between phase conductors for which the cable accessory is designed; and
c) $U_m$ the maximum value of the 'highest system voltage' between phase conductors for which the cable accessory may be used.

### 5.2 Current Rating

The continuous current rating of a joint or outdoor termination shall be in accordance with the relevant standard as applicable shall be suitable for operation at the temperatures given in Table 1 for continuous duty and under short-circuit conditions.

**Table 1 Maximum Rated Conductor Temperatures**

| Sl No. | Rating | Insulation Type | |
|---|---|---|---|
| | | Extruded Solid Dielectric XLPE /EPR | PVC |
| (1) | (2) | (3) | (4) |
| i) | Continuous | 90 °C | 70 °C |
| ii) | Short-circuit | 250 °C | 160 °C |

## 6 REQUIREMENTS

Joints, stop ends and outdoor terminations complying with this standard shall meet the following requirements.

### 6.1 General

The range of compliance shall include the cable conductor cross-sections tested, together with the intermediate cross-sections.

Any successful test sequence carried out on only one cable cross-section shall give compliance for that cross-section only.

Compliance with this standard for an accessory for a particular type of cable insulation extends to other types of insulation according to Table 2.

Compliance obtained for a cable with one type of sheathing material shall not be extended to an otherwise identical cable incorporating a different sheathing material.

### Table 2 Summary of Compliance with Different Cable Insulations

(*Clause* 6.1)

| Sl No.<br>(1) | Cable Insulation<br>(2) | Range of Approval<br>(3) |
|---|---|---|
| i) | XLPE | XLPE, EPR, HEPR, PVC |
| ii) | EPR, HEPR | EPR, HEPR, PVC |
| iii) | PVC | PVC |

NOTE — It should be noted that adhesion between the cable insulation and the accessory filling compound is critical for the performance of some joint designs.

Compliance obtained by testing on a non water-blocked type of cable shall be extended to a water-blocked cable that is otherwise of the same design. The converse shall not apply.

Joints and stop ends shall normally be designed and tested to withstand a height of water of 1 000 mm [10 kPa (0.1 bar)].

For special applications and in situations subject to a high water table or prone to flooding, this height of water may be insufficient to ensure the satisfactory performance of the moisture seals. In such cases, upon agreement between manufacturer and the user, the accessories shall be tested using an increased water height of 10 000 mm [100 kPa (1.0 bar)]. The chosen water height shall be recorded in the test report.

Testing at one water height will achieve compliance for that pressure only. Testing at both 1 000 mm and 10 000 mm water heights will achieve compliance for those water heights and all intermediate pressures.

Compliance will be gained for a range of accessories of the same design and materials for a given cable type and for a range of conductor cross-sections (copper and aluminium), providing the appropriate samples have successfully undergone the appropriate test sequence in Tables 3, 4 or 5.

### 6.2 Joints and Stop Ends

Compliance for branch joints for a given range of cable cross-sections may be extended to straight joints and stop ends for the same range of cable cross-sections, if it can be shown that the construction is similar and the seals are of the same type and not inferior to those of the branch joints tested.

### 6.3 Transition Joints

To be tested under agreement between the purchaser and the supplier.

### 6.4 Packaging, Marking and Labelling, and Information Provided by Manufacturer

**6.4.1** *Packaging*

Packaging shall be adequate to ensure that any stated shelf life is maintained when the accessory is stored under covered, dry conditions within the stated ambient air temperatures, such that the performance of the components forming part of the total accessory is unaffected.

**6.4.2** *Marking and Labelling*

Individual accessory kits on the outside of the packaging shall contain the following information and all the kits are to be suitably labelled for identification purpose with the following details:

a) Manufacturer's name or logo and the name of components wherever feasible;
b) Type of jointing materials, the application;
c) Batch number(s), where relevant;
d) Product reference;
e) Defined storage conditions and expiry date, if any;
f) If relevant, the manufacturing date;
g) Health and safety marking and handling instructions, where relevant; and
h) Reference to compliance with this standard.

Inside the packaging,

a) list of contents;
b) installation instructions, including drawings or other information specific to the accessory.

Where practicable, joint shells or outer coverings shall be permanently and legibly marked with a reference that will enable the range of cables for which the joint is suitable to be identified from the manufacturer's literature.

If conductor connectors are included they shall be permanently and legibly marked/embossed with the conductor type and cross-section, or a reference number that will enable this information to be obtained from the manufacturer's literature.

**6.4.3** *Health and Safety*

The manufacturer shall make available such information as will enable the purchaser to use and dispose of any materials in a safe manner in accordance with relevant legislation.

## 7 TYPE TESTS

### 7.1 General

Written reports on type tests proving compliance with this standard shall be made available by the manufacturer. The principal details of the test arrangements shall be given in the test report, including, for example, cross-sections of conductors, model and type of connector, minimum clearance between joint and shell, wherever applicable, as shown in the manufacturers drawing. The test reports shall be signed by a representative of the body carrying out the tests. This may be the manufacturer or a recognized certification body.

Should a cable fail beyond any part of an accessory, the test shall be declared void without discrediting the accessory. Tests may be repeated using a new accessory (reverting to the beginning of the test sequence) or alternatively by repair of the cable (continuing testing from the point of suspension).

### 7.2 Sequence of Tests

The test sequence shall be in the order given in Tables 3 to 5, as appropriate for the accessory being tested.

### 7.3 Test Samples

The number of samples required for each test sequence shall be in accordance with Tables 6 to 9.

Cables used for testing shall comply with IS 1554 (Part 1), IS 7098 (Part 1), IS 9968 (Part 1) and IS 14255 (No tests on messenger conductor) and shall be identified in the test report with respect to,

a) rated voltage;
b) material, shape and cross-section of conductors;
c) details of construction (insulation and sheath, number of cores, armour, inner sheath, outer sheath, water-blocking, etc); and
d) principal cable dimensions.

The connecting components used in a joint or termination shall comply with **4.1**.

Accessories to be tested shall be correctly identified in accordance with **6.4.2**.

Accessories shall be assembled in the manner specified in the manufacturer's instructions, using the components supplied in the kit.

Accessories shall be dry and clean, but neither the cable nor the accessories shall be subjected to any form of conditioning which may modify the electrical, thermal or mechanical performance of the test assemblies.

Relevant details regarding the test installation shall be recorded in the test report for future reference and to ensure repeatability of the test regime.

**Table 3 Test Sequence for Joints for Solid Extruded Dielectric Insulated Cables**

(*Clauses* 6.1 *and* 7.2)

| Sl No. | Test | Samples<br>Type of Joints[1] | | | | Requirements |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| | | A1/B1 | A1/B1 | A1/B1 | A2/B2 | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| i) | Impulse voltage withstand at ambient temperature (*see* **8.2**) | — | — | X | — | No failure |
| ii) | Heating cycle in air (*see* **8.3**) | X | X | X | — | — |
| iii) | Heating cycle in water (oversheath damage) (*see* **8.3**) | X | X | X | — | — |
| iv) | Insulation resistance (immersed) (*see* **8.4**) | — | X | — | — | Insulation resistance ≥ 50 MΩ |
| v) | Insulation resistance (in air) (*see* **8.4**) | X | X | X | — | Insulation resistance ≥ 50 MΩ |
| vi) | Insulation resistance (immersed) (*see* **8.4**) | X | X | X | — | Insulation resistance ≥ 50 MΩ |
| vii) | Impact at ambient temperature (*see* **8.5**) | — | X | — | — | — |
| viii) | ac voltage withstand (immersed) (*see* **8.6**) | — | X | — | — | No failure |
| ix) | ac voltage withstand (in air) (*see* **8.6**) | X | X | X | — | No failure |
| x) | ac voltage withstand (immersed) (*see* **8.6**) | X | X | X | — | No failure |
| xi) | Examination [2] (*see* **8.8**) | X | X | X | — | For information only [3] |
| xii) | Screen short-circuit [4] (*see* **8.9**) | — | — | — | X | The fuse shall operate before an open circuit develops between the test pin and the screen. |

[1] For the definitions of Types I, II and III, *see* **3.1.1** to **3.1.3**, and for the explanation of A1/B1, A2/B2 *see* Tables 6 and 7.

[2] For cast resin joints visual examination only is required. No cracks are allowed, but when a joint contains solid cured resin damage to the mould may be ignored.

[3] The accessory shall be examined and the following information reported in the test report:
a) cracking of filling media and/or tape or tubing components;
b) a moisture path across a primary seal;
c) corrosion which would, in time, lead to failure of the joint;
d) leakage of any insulating material.

[4] This test is required for joints incorporating an overall metallic screen only and is subject to agreement.

### Table 4 Test Sequence for Stop Ends on Solid Extruded Dielectric Insulated Cables

(*Clauses* 6.1 *and* 7.2)

| Sl No. | Test | Samples<br>Type of Stop End 1) | | Requirements |
|---|---|---|---|---|
| | | I<br>C1 | II<br>C1 | |
| (1) | (2) | (3) | (4) | (5) |
| i) | Impulse voltage withstand at ambient temperature (*see* **8.2**) | — | X | No failure |
| ii) | Insulation resistance (immersed) (*see* **8.4**) | X | X | Insulation resistance ≥ 50 MΩ |
| iii) | Insulation resistance (in air) (*see* **8.4**) | X | X | Insulation resistance ≥ 50 MΩ |
| iv) | Impact at ambient temperature (*see* **8.5**) | X | — | |
| v) | ac voltage withstand (in air) (*see* **8.6**) | X | X | No failure |
| vi) | ac voltage (immersed) (*see* **8.6**) | X | X | No failure |
| vii) | ac voltage withstand (immersed) (*see* **8.6**) | X | X | No failure |
| viii) | Immersion (*see* **8.7**) | X | X | |
| ix) | Examination 2) (*see* **8.8**) | X | X | For information only 3) |

1) For the definitions of Types I and II, *see* **3.5.1** to **3.5.2**, and for the explanation of C1 *see* Table 8.

2) For cast resin stop-end visual examination only is required. No cracks are allowed, but when a stop-end contains solid cured resin damage.

3) The accessory shall be examined and the following information reported in the test report:

a) cracking of filling media and/or tape or tubing components;
b) a moisture path across a primary seal; and
c) corrosion which would, in time, lead to failure of the stop-end.

4) Leakage of any insulating material to the housing may be ignored.

### Table 5 Test Sequence for Outdoor Terminations on Solid Extruded Dielectric Insulated Cables

(*Clauses* 6.1 *and* 7.2)

| Sl No. | Test | Samples<br>Type of Termination 1) | | Requirements |
|---|---|---|---|---|
| | | I<br>D1 | II<br>D1 | |
| (1) | (2) | (3) | (4) | (5) |
| i) | Impulse voltage withstand at ambient temperature (*see* **8.2**) | — | X | No failure nor flashover |
| ii) | Heating cycle (in air) (*see* **8.3**) | X | X | — |
| iii) | Heating cycle (Crutch immersed) (*see* **8.3**) | X | X | — |
| iv) | Insulation resistance (in air) (*see* **8.4**) | X | X | Insulation resistance ≥ 50 MΩ |
| v) | Insulation resistance (crutch immersed) (*see* **8.4**) | X | X | Insulation resistance ≥ 50 MΩ |
| vi) | ac voltage withstand (in air) (*see* **8.6**) | X | X | No failure |
| vii) | ac voltage withstand (Crutch immersed) (*see* **8.6**) | X | X | No failure |
| viii) | Examination 2) (*see* **8.8**) | X | X | For information only 2) |

1) For the definitions of Types I and II, *see* **3.7.1** to **3.7.2**, and for the explanation of D1 *see* Table 9.

2) The accessory shall be examined and the following information reported in the test report:

a) cracking of filling media and/or tape or tubing components;
b) a moisture path across a primary seal;
c) corrosion which would, in time, lead to failure of the termination; and
d) leakage of any insulating material.

## 8 TEST METHODS

### 8.1 General

**8.1.1** *Test Conditions*

Tests shall be made at an ambient temperature within the range 20 ± 15°C, unless otherwise stated in the details of a particular test.

Tap water shall be used for all tests in water.

The frequency and waveform of power frequency test voltages shall be in accordance with IS 2071 (Part 1).

The test shall be started not less than 24 h after the installation of the accessories on the cable test loops, unless otherwise specified by the manufacturer.

Cable screen and armour, if any, shall be bonded and earthed at one end only to prevent circulating currents.

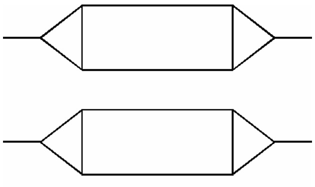
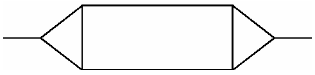
**8.1.2** *Temperature Calibration of Cable*

**8.1.2.1** *Application*

All cables heated in the test sequences.

## Table 6 Number of Test Samples and Conductor Cross-section: Straight Joints

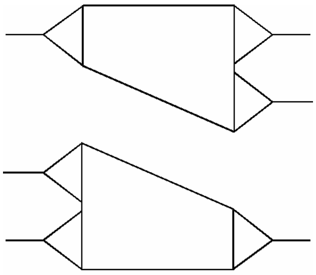
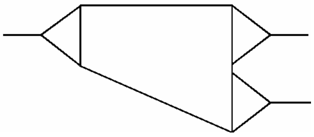
(*Clause* 7.3; and *Table* 3)

| Sl No. | Sequence | Tests | Symbol | Number of Test Samples and Conductor Cross-section[1] |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | A1 | General test sequence |  | 2 samples:<br>a) One sample with smallest conductor cross-section<br>b) One sample with largest conductor cross-section |
| ii) | A2 | Screen short-circuit |  | Two samples with conductor cross-section ≥ 150 mm$^2$ |

[1] Copper or aluminium.

## Table 7 Number of Test Samples and Conductor Cross-section: Branch Joints

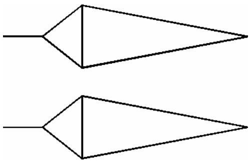
(*Clause* 7.3; and *Table* 3)

| Sl No. | Sequence | Tests | Symbol | Number of Test Samples and Conductor Cross-section[1] |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | B1 | General test sequence |  | 2 samples:<br>a) One sample with smallest main conductor cross-section and with smallest branch conductor cross-section<br>b) One sample with largest main conductor cross-section and with smallest branch conductor cross-section |
| ii) | B2 | Screen short-circuit |  | Two samples with conductor cross-section ≥ 150 mm$^2$ |

[1] Copper or aluminium.

## Table 8 Number of Test Samples and Conductor Cross-section: Stop Ends

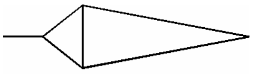
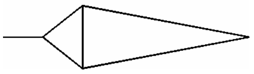
(*Clause* 7.3; and *Table* 4)

| Sl No. | Sequence | Tests | Symbol | Number of Test Samples and Conductor Cross-section[1] |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| i) | C1 | General test sequence |  | 2 samples:<br>a) One sample with smallest conductor cross-section<br>b) One sample with largest conductor cross-section |

[1] Copper or aluminium.

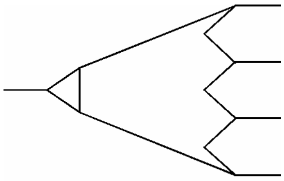
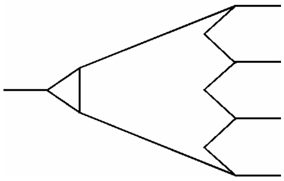
### Table 9 Number of Test Samples and Conductor Cross-section: Outdoor Terminations

(*Clause* 7.3; and *Table* 5)

| Sl No. (1) | Sequence (2) | Tests (3) | Symbol (4) | Number of Test Samples and Conductor Cross-section[1] (5) |
|---|---|---|---|---|
| i) | D1 | General test sequence | <br> | 2 samples:<br>a) One sample with smallest conductor cross-section<br>b) One sample with largest conductor cross-section |

[1] Copper or aluminium.

Or

| Sl No. (1) | Sequence (2) | Tests (3) | Symbol (4) | Number of Test Samples and Conductor Cross-section[1] (5) |
|---|---|---|---|---|
| i) | D1 | General test sequence | <br> | 2 samples:<br>a) One sample with smallest conductor cross-section<br>b) One sample with largest conductor cross-section |

[1] Copper or aluminium.

**8.1.2.2** *Purpose*

The purpose is to enable the measurement of conductor temperature during the heating cycle test given in **8.3** by monitoring the temperature of the sheath when a control cable is not used for the test.

**8.1.2.3** *Test procedure*

Temperature calibration of cable shall be carried out before the test sequence by application of the Method 1 or 2 given in Annex A, or by any equivalent method.

## 8.2 Impulse Voltage Withstand Test at Ambient Temperature

**8.2.1** *Purpose*

This test is used as a screening test required to check, before running the full test sequence, that the accessory meets the network impulse requirements.

**8.2.2** *Test Installation*

The accessory shall be installed on a test loop in accordance with the manufacturer's installation instructions.

**8.2.3** *Test Procedure*

The test shall be conducted at ambient temperature as defined in **8.1.1**.

Impulses shall be applied to each phase in turn with the other phases, neutral and screen earthed.

A series of 10 positive and 10 negative impulses shall be applied at the values given below:

a) 8 kV for accessories installed on a main cable with a conductor cross-section $\leq 50$ mm$^2$.
b) 20 kV for accessories installed on a main cable with a conductor cross-section $> 50$ mm$^2$.

NOTE — In the case of a branch joint, the conductor cross-section of the branch cable is not relevant.

## 8.3 Heating Cycle Test

**8.3.1** *Purpose*

The heating cycle test aims, in a short time, to simulate the operating stresses experienced by accessories during their service life, through the thermomechanical effects produced during the alternating heating and cooling phases.

**8.3.2** *Test Installation*

The test shall be carried out on the accessories being subjected to the main test sequence. The conductor temperature should be determined according to one of the three methods given in Annex A.

For Methods 1 and 2, the arrangements are shown in Fig. 2, 3 and 4 and the electrical connections for various accessories are shown in Fig. 5 to 8.

The conductor temperature shall be monitored by measuring the temperature of the sheath of the external cable by a thermocouple attached to the sheath 1 000 mm (minimum) outside the accessory for tests in air or 500 mm (minimum) above the water level for tests in water and 500 mm (minimum) from the external crutch, as shown in Fig. 2 and 3. The conductor temperature shall be established from the relationship derived in the test given in **8.1.2**. If the ambient temperature varies by more than 10°C from the temperature at which the calibration test given in **8.1.2** was carried out, a further calibration shall be made.

**8.3.3** *Test Procedure*

The total cycle shall be completed within 8 h. A typical heating and cooling cycle is shown in Fig. 9.

Joints shall be subjected to 63 cycles in air followed by 63 cycles immersed in water. Branch cables $\leq 50\ \text{mm}^2$ shall not be heated.

Outdoor terminations shall be subjected to 63 cycles in air followed by 63 cycles with the crutch only immersed. For convenience, the 'in air' cycles may be carried out in the tank (without water), but provision shall be made to allow air circulation.

NOTE — Care should be exercised if cable incorporates magnetic armouring.

**8.3.3.1** *In air*

The temperature of the main conductors (and branch conductors when $> 50\ \text{mm}^2$) shall be raised to between 5 and 10°C above the maximum rated temperature by heating the assembly, by passing current through the cables, as shown in Fig. 5 to 8, as appropriate. A steady conductor temperature shall be maintained for not less than 2 h. After the 2 h minimum steady temperature period the current shall be switched off and the cable allowed to cool naturally to within 10°C of ambient within a period not less than 3 h. Forced cooling shall not be used.

**8.3.3.2** *In water*

*Joints*: The core(s) of one polymeric insulated cable shall be exposed at the entry to the joint by removing an annulus of the oversheath together with any bedding or filling material of at least 50 mm length at a point which will be within the water and between 50 mm and 150 mm from the exterior of the accessory. The exposure of the core(s) shall be made on the side with the shorter sealing length between the sheath cut back and connectors. The assembly shall be placed in a water bath (or pressure vessel) with a water height of $h = 1\ 000^{+20}_{-0}$ mm or other wise specified above the main cable entry (*see* **6.1**).

The over sheath damage requirement does not apply to water-blocked cable designs.

*Outdoor terminations*: The thermocouple shall be placed as shown in Fig. 4. The water height over the crutch shall be $h = 300 \pm 100$ mm.

During the heating cycle the temperature of the water shall be 20 ± 15°C.

Conductor temperatures shall be recorded during each of the 126 cycles. Any cycle during which the specified minimum conductor temperature is not reached shall be rejected and additional cycles carried out to achieve the specified number.

### 8.4 Insulation Resistance Test

**8.4.1** *Purpose*

To ensure that the insulation resistance has not been impaired by the mechanical and electrical tests.

**8.4.2** *Test Installation*

Assemblies subjected to the test sequences.

**8.4.3** *Test Procedure*

Insulation resistance shall be measured using an instrument with an operating voltage in the range 100 V to 1 000 V dc.

The dc test voltage shall be applied for sufficient time to reach a steady measurement, but for not less than 1 min and not more than 5 min. Insulation resistance measurements shall be made at ambient temperature.

**8.4.3.1** *Prior to immersion in water*

The insulation resistance shall be measured between each phase conductor in turn and the other phase conductors, and between the bunched phase cores and all other metallic parts.

For the purpose of this part of the test the neutral shall be treated as another phase core.

**8.4.3.2** *After immersion in water*

The insulation resistance shall be measured between each phase conductor in turn and the other phase conductors, and between the bunched phase conductors and all other metallic parts and water.

For the purpose of this part of the test the neutral shall be treated as another phase conductor providing the sheath damage in the load cycling test has not brought it in contact with the water (that is in the case of cables with a concentric neutral). If the neutral is in contact with the water it shall be bunched with the other metallic parts.

### 8.5 Impact at Ambient Temperature

Following two categories of joints or stop ends are considered:

a) Rigid joints and stop ends; and

b) Non-rigid joints and stop ends, incorporating a metallic earth screen.

**8.5.1** *Purpose*

The purpose of this test is to demonstrate the mechanical strength of the joint or stop end at ambient temperature.

**8.5.2** *Test Installation*

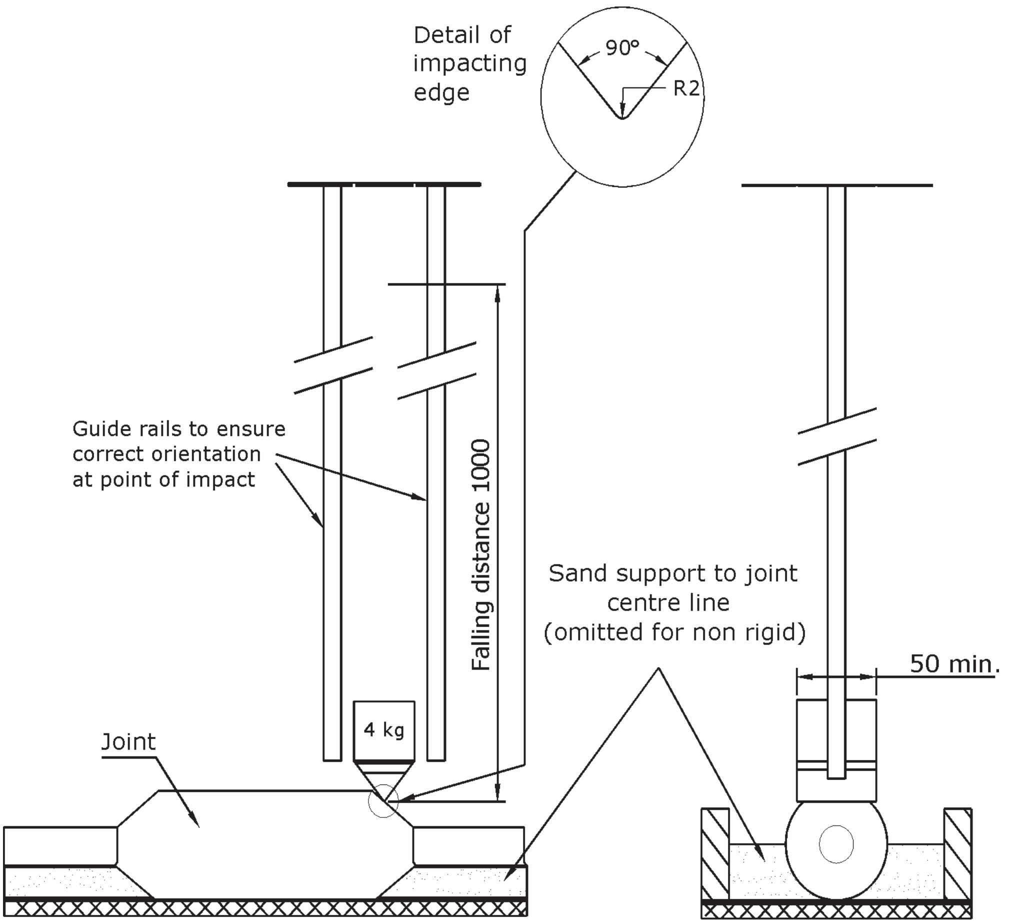
The test shall be performed on all joints or stop ends to be subjected to the main test regime. The number of impacts shall be as specified below.

**8.5.3** *Test Procedure*

**8.5.3.1** *Rigid joints and stop ends*

The accessory shall be placed in a box on a hard surface, for example a concrete slab or floor, and the box shall be filled with sand to the horizontal centre of the accessory as shown in Fig. 1.

The impacting tool shall be a wedge-shaped steel block of 4 kg mass having a 90° angle with a 2 mm radius impacting edge of minimum width 50 mm. The block shall be dropped onto the accessory from a height of $1\,000^{+20}_{-0}$ mm, so that the impacting edge is horizontal,


Detail of impacting edge
90°
R2
Guide rails to ensure correct orientation at point of impact
Falling distance 1000
Sand support to joint centre line (omitted for non rigid)
50 min.
4 kg
Joint

All dimensions in millimetres.

FIG. 1 ARRANGEMENT FOR THE IMPACT TEST AT AMBIENT TEMPERATURE

at right angles to the axis of the accessory, and centered on the point of impact.

The impact shall be made at the mid-point of the primary moisture seal at each cable entry, and in the middle of the joint near to the connector(s).

The accessory shall be immersed in water with a height of $1\,000^{+20}_{-0}$ mm above the cable entry or such other height as specified, for a minimum of 3 h before carrying out the a.c. voltage and insulation resistance tests. The time of immersion may be extended over one night for convenience.

**8.5.3.2** *Non-rigid joints and stop ends*

The accessory shall be placed on a hard surface, for example a concrete slab or floor.

The impacting tool shall be a wedge-shaped steel block of 4 kg minimum having a 90° angle with a 2 mm radius impacting edge of minimum width 50 mm. The block shall be dropped onto the accessory from a height of $1\,000^{+20}_{-0}$ mm so that the impacting edge is horizontal, at right angles to the axis of the accessory, and centered on the point of impact.

The impact shall be made at each cable entry within 10 mm of the edge of the oversheath on the joint side. In addition one impact shall be made over the connector(s).

As far as practicable the accessory, at the point of impact, shall be in contact with the floor.

The accessory shall be immersed in water with a height of $1\,000^{+20}_{-0}$ mm above the cable entry or such other height as specified, for a minimum of 3 h before carrying out the ac voltage and insulation resistance tests. The time of immersion may be extended over one night for convenience.

### 8.6 ac Voltage Withstand Test

**8.6.1** *Purpose*

The purpose of the test is to assess the integrity of the insulation early in the test sequence and to identify deterioration of the insulation as a result of the mechanical and thermal stresses introduced during the tests.

**8.6.2** *Test Installation*

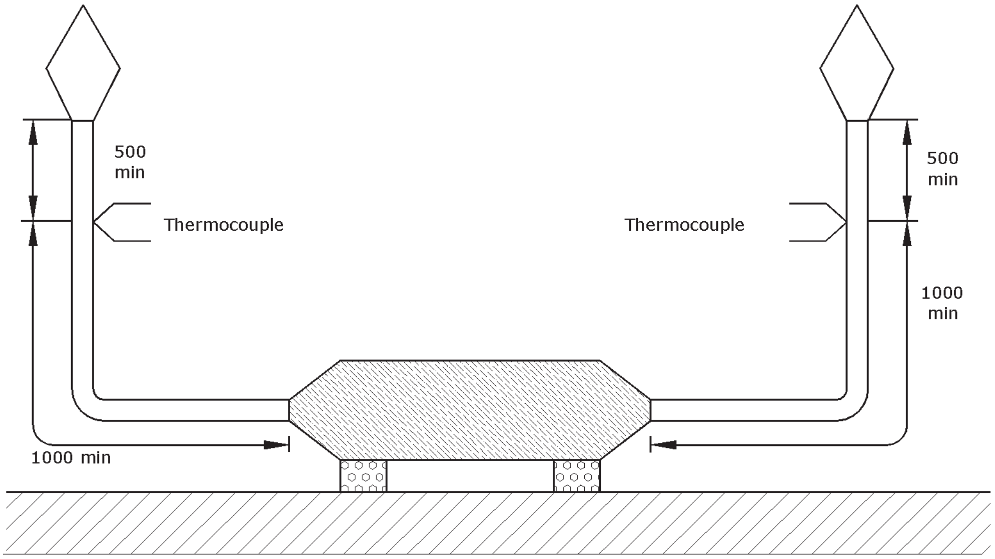
*Joints and stop ends*: The test shall be carried out while immersed in the water bath (or pressure vessel), or in air as specified in Tables 3 and 4. For immersion depth *see* Fig. 3.

*Outdoor terminations*: The test shall be carried out in air or with the crutch immersed in water as specified in Table 5. For immersion depth *see* Fig. 4.

**8.6.3** *Test Procedure*

An ac voltage of 4 kV shall be applied for 1 min between the bunched phase conductors and all other metallic parts and the water (if appropriate).

An ac voltage of 4 kV shall be applied for 1 min



All dimensions in millimetres.

NOTE — For convenience, this part of test may be conducted in the tank (without water).

FIG. 2 TYPICAL ARRANGEMENT FOR THE HEATING CYCLE IN AIR

between each phase conductor in turn and all other phase conductors, metallic parts and water earthed.

In situations where the neutral is insulated from the water, the neutral shall be treated as another phase conductors for the purposes of this test.

### 8.7 Immersion Test

**8.7.1** *Purpose*

The purpose of the test is to prove the satisfactory moisture ingress performance of the stop ends.

**8.7.2** *Test Installation*

The cores of the cable shall be exposed by removing an annulus of the oversheath and any bedding or filling material over a length of at least 50 mm, starting at a point 50 mm from the cable entry.

The oversheath damage requirement does not apply to water-blocked cable designs.

The test sample shall be immersed in a water bath (or pressure vessel) with a height of 1 000 mm, or as otherwise specified, above the cable entry of the stop end (*see* **6.1**). The sample shall remain immersed for 21 days and during this time the temperature of the water shall remain in the range 20 ± 15°C.

After 21 days the sample shall undergo the ac voltage withstand test specified in **8.6** followed by insulation resistance measurement in accordance with **8.4** while still immersed in the water bath.

### 8.8 Examination

**8.8.1** *Purpose*

The purpose of the examination is to ascertain whether any deterioration has taken place in the accessory which may affect its long term service life.

**8.8.2** *Examination Objects*

The joints and outdoor terminations which have been subjected to the heating cycle test and stop ends which have been subjected to the immersion test shall be sectioned and examined.

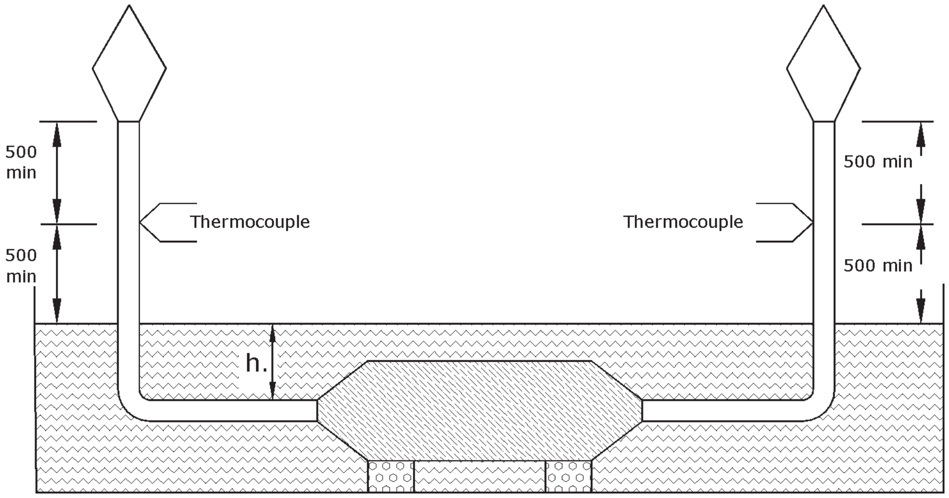
**8.8.3** *Procedure*

**8.8.3.1** *Rigid joints and stop ends*

Dismantle the assemblies and examine the joint.

Section the joint at right angles to the cable axis at the position of the phase conductor connector(s) and at the ends of the oversheath (polymeric insulated cables) or the metallic sheath (paper insulated cables). Make two cuts at each position to give a cross-section of the joint approximately 25 mm thick.

Visually examine the encapsulant exposed at the sectioned ends of the joint for cracks and large voids and if any are present, record details.



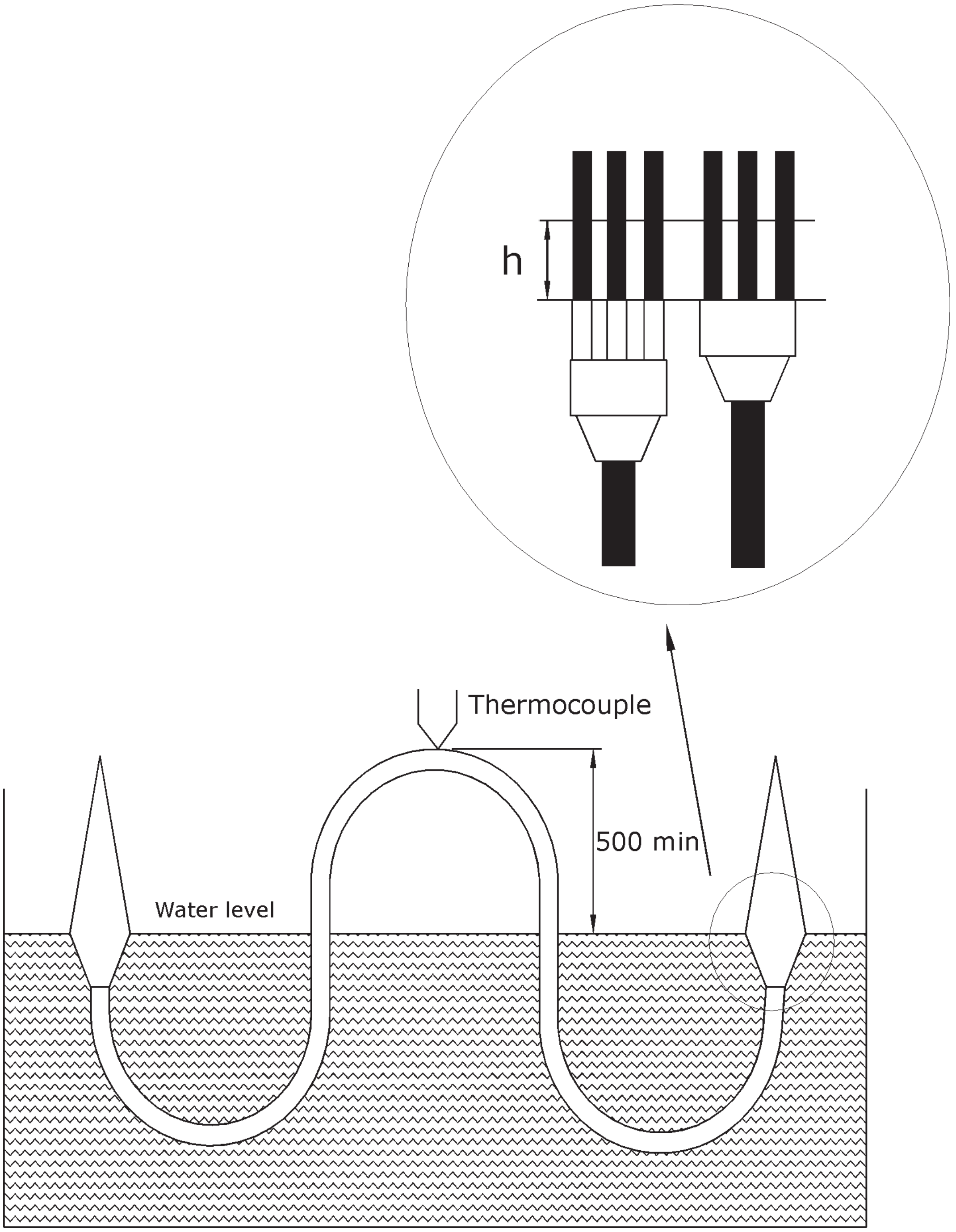
All dimensions in millimetres.

NOTES

**1** *h* = height of water, as specified in **6.1** and **8.6.3**.

**2** If pressure vessel is used it shall incorporate of registering pressure and water level.

FIG. 3 TYPICAL ARRANGEMENT FOR THE HEATING CYCLE FOR JOINTS IN WATER



All dimensions in millimetres.

NOTE — *h* = height of water (*see also* **8.3.3**).

FIG. 4 TYPICAL ARRANGEMENT FOR THE HEATING CYCLE FOR OUTDOOR TERMINATIONS IN WATER

Examine the cross-section of each joint cable entry for water ingress between the encapsulant and the cable sheath. Make two cuts approximately 45° apart around the circumference down to the cable sheath. If possible, pull the 45° segment of encapsulant away from the cable sheath and scrutinize the interface surfaces that are consequently exposed for moisture.

Examine the metalwork and in particular any neutral conductor or earth bonds for corrosion and record the results of the examination.

NOTE — Where practicable the sectioning should be carried out using hand tools rather than power tools, to avoid evaporating any moisture.

**8.8.3.2** *Non-rigid joints and stop ends*

Examine the joint for the effectiveness of the moisture seals and corrosion of the armour bonds and other metalwork exposed within the joint casing.

Check the outer sleeve or protection for any splits and then remove it where it overlaps the cable over sheath.

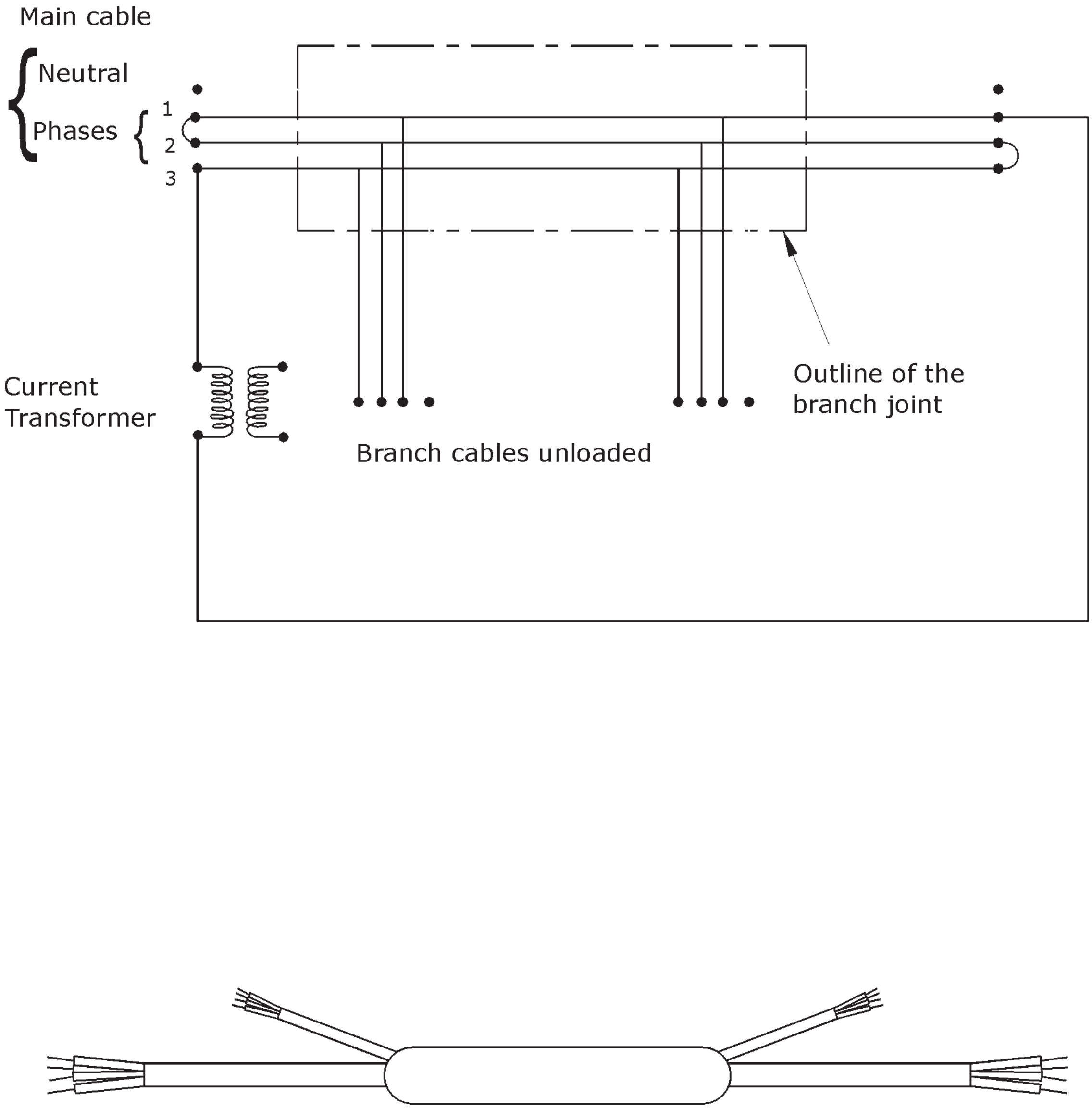


FIG. 5 METHOD OF CONNECTION FOR THE HEATING CYCLE TEST ON BRANCH JOINT WHERE THE MAIN CABLE CONDUCTOR CROSS-SECTION IS GREATER THAN 50 mm$^2$ AND THE BRANCH CABLE CONDUCTOR CROSS-SECTION IS LESS THAN OR EQUAL TO 50 mm$^2$ (EXAMPLE ONLY)

If the outer sleeve or protection comprises more than one component (for example, two sleeves over lapped), similarly examine the seal(s) between the components.

Remove the joint case (sleeve plus any metallic casing) to allow examination of the jointed conductors and any metalwork, for example armour bonds.

Remove the primary insulation over each conductor connector (using heat, if necessary) and examine the seals.

Examine the metalwork, and in particular any neutral conductor or earth bonds for corrosion and record the results of the examination.

NOTE — Since the design of the joint may allow moisture to enter the joint from the cable, it is essential that the primary insulation seals are shown to be effective in preventing moisture reaching the conductor connectors.

**8.8.3.3** *Outdoor terminations*

The termination shall be dismantled and all components shall be examined for traces of moisture within water-proofing components. The results of the examination shall be recorded.

## 8.9 Metallic Screen Short-Circuit Current Withstand Test

**8.9.1** *Purpose*

To check that when the joint is pierced by a metallic

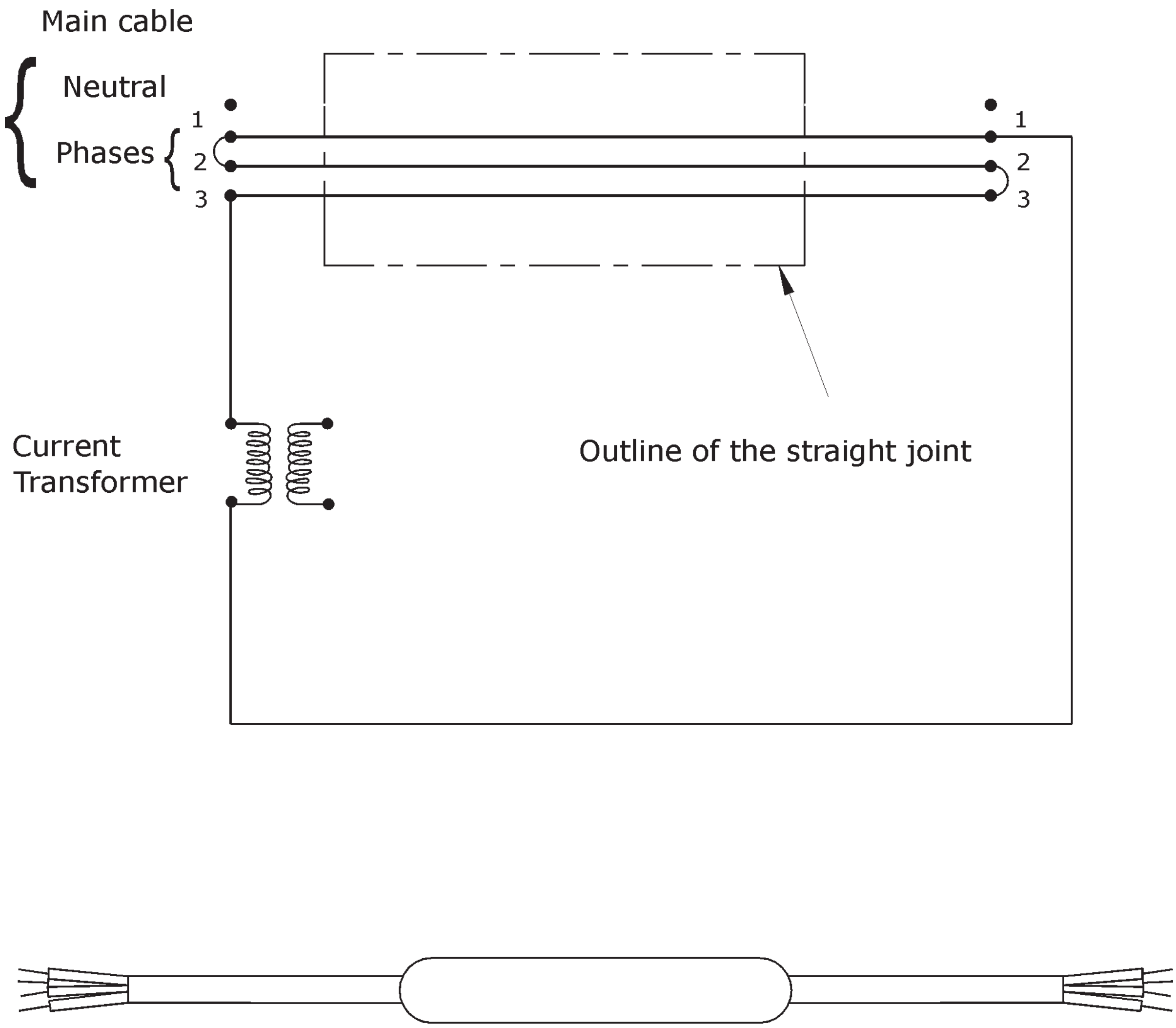


FIG. 6 METHOD OF CONNECTION OF THREE PHASE CABLES FOR THE HEATING CYCLE TEST ON A STRAIGHT JOINT (EXAMPLE ONLY)

hand tool the circuit protection operates before disintegration of the screen. It is applicable to straight and branch joints only where the conductor cross-section is 150 mm$^2$ and above, on networks protected by fuses. The size of fuse to be used in the test shall be subject to agreement between the customer and the manufacturer.

**8.9.2** *Test Installation*

The general arrangement of the test joint, including resistance and fuse, is shown in Fig. 10.

Two joints shall be made which shall be additional to those subjected to the main test regime.

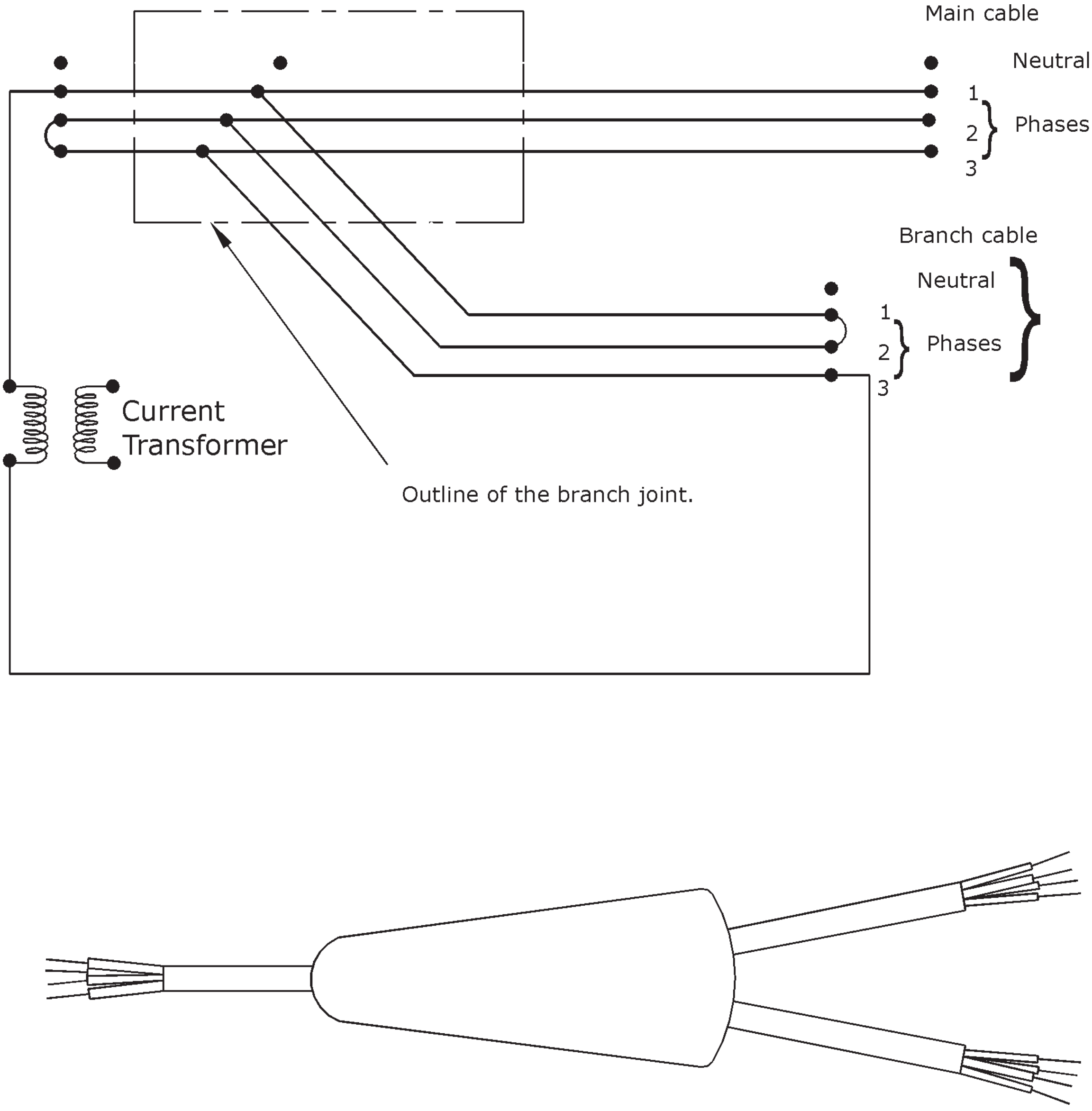


Fig. 7 Method of Connection of Three Phase Main and Branch Cables of Equal Conductor Cross-Section for Heating Cycle Test on a Branch Joint (Example Only)

During the making of each joint, a length of insulated copper braid or conductor of a minimum cross-sectional area of 50 mm$^2$ shall be connected to one phase and brought out of the joint to be connected to a 8 mm diameter copper test pin.

A hole of maximum diameter 6 mm shall be drilled into the joint so that the test pin may be inserted to make connection with the screen.

**8.9.3** *Test Procedure*

The current source shall be set up to deliver a phase to earth short-circuit current, $I_{sc}$, the value to be agreed between the customer and the manufacturer. The open circuit voltage between the test phase and earth shall be 230 V.

The short-circuit current and the voltage shall remain in phase throughout the test.

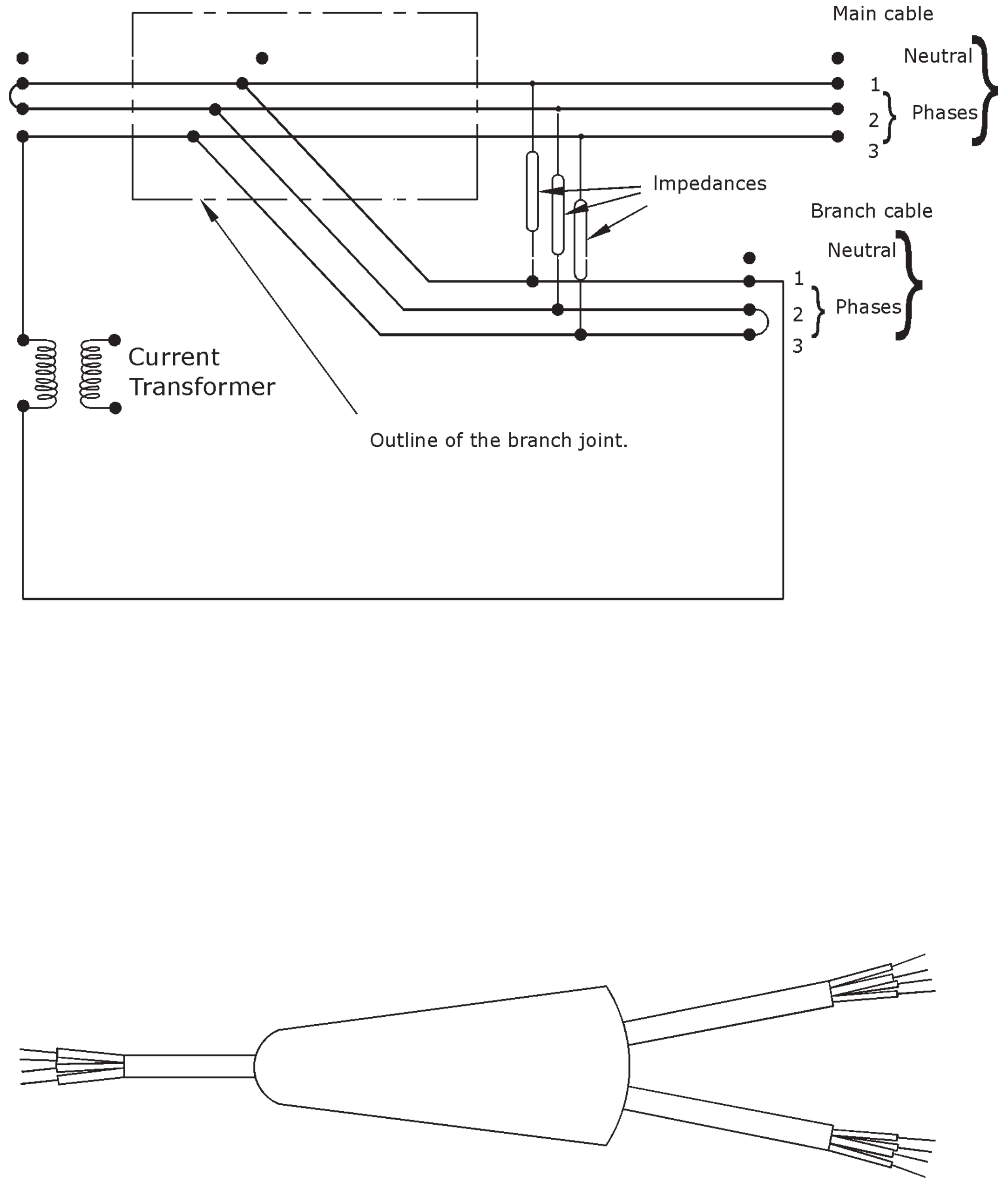


FIG. 8 METHOD OF CONNECTION OF THREE PHASE MAIN AND BRANCH CABLES OF UNEQUAL CONDUCTOR CROSS-SECTION FOR HEATING CYCLE TEST ON A BRANCH JOINT (EXAMPLE ONLY)

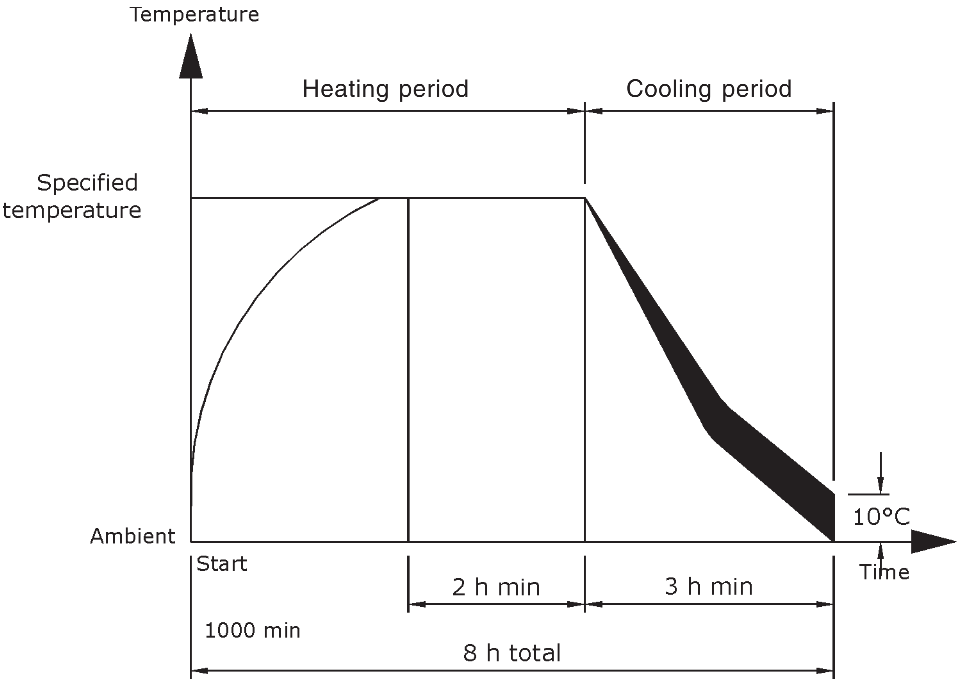


FIG. 9 TYPICAL HEATING CYCLE

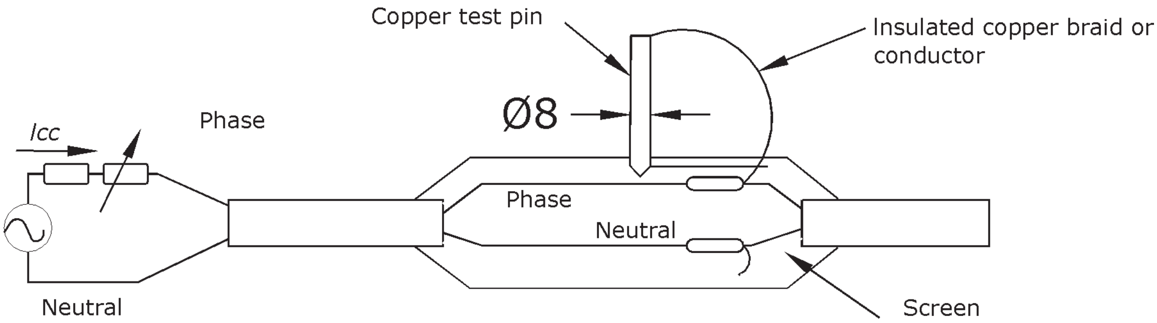


FIG. 10 ARRANGEMENT FOR THE SCREEN SHORT-CIRCUIT TEST

# ANNEX A

(*Clauses* 8.1.2.3 *and* 8.3.2)

## DETERMINATION OF THE CABLE CONDUCTOR TEMPERATURE

### A-1 PURPOSE

For some of the accessory tests, it is necessary to raise the cable conductor to a given temperature, typically 5 to 10°C above the maximum temperature in normal operation, while the cable is energized, either at power frequency or under impulse conditions. It is therefore not possible to have access to the conductor to enable direct measurement of temperature.

In addition, the conductor temperature should be maintained within a restricted range (5°C), whereas the ambient temperature may vary over a wider range.

Thus, it is necessary to carry out a preliminary calibration on the test cable to determine the actual conductor temperature during the accessory tests, allowing for the permitted variation in ambient temperature.

Guidance is given hereafter on commonly used methods.

### A-2 CALIBRATION OF THE TEST CABLE CONDUCTOR TEMPERATURE

The purpose of the calibration is to determine the conductor temperature by direct measurement for a given current, within the temperature range required for the test.

The cable used for calibration should be identical to that to be used for the accessory test.

### A-2.1 Installation of Cable and Thermocouples

The calibration should be performed on a minimum cable length of 2 m, the thermocouples being installed at 0.5 m from the cable ends, as shown in Fig. 11.

At each place, two thermocouples should be attached: one on the conductor (*a*), and one on the external surface (*b*), as shown in Fig. 12.

It is recommended that the thermocouples are attached to the conductor by mechanical means since they may move due to vibrations of the cable conductor during heating.

If the actual test loop includes several individual cable lengths installed close to each other, these lengths will be subjected to thermal proximity effect. The calibration should therefore be carried out taking account of the actual test arrangement, measurements being performed on the hottest cable length (usually the middle length).

NOTE — The thermocouples (*b*) on the external surface are only necessary, if method **A-3.2** is used.

### A-2.2 Method

The calibration should be carried out in a draught free situation at a temperature between 5°C and 35°C.

Temperature recorders should be used to measure the conductor, sheath and ambient temperatures.

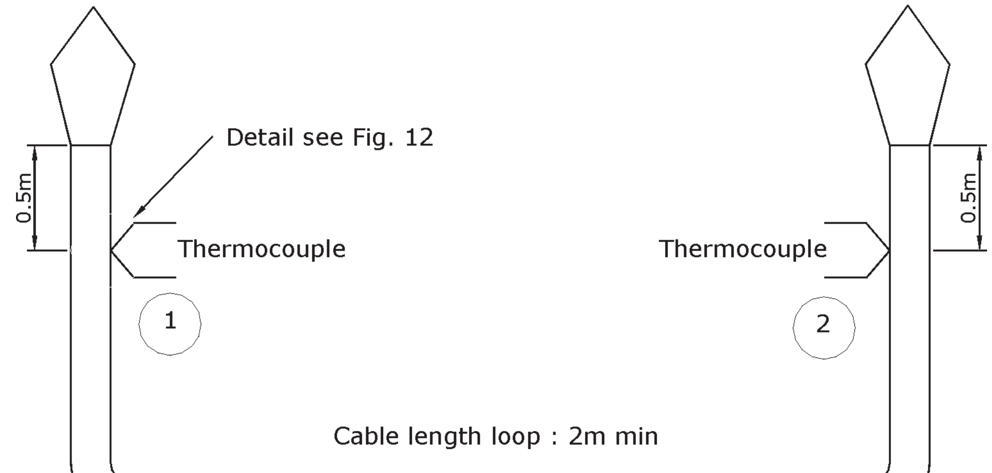


FIG. 11 REFERENCE CABLE

The cable should be heated until the conductor temperatures $a_1$ and $a_2$, indicated by thermocouples (a) at positions 1 and 2 of Fig. 11, have stabilized and reached the temperatures between 5°C and 10 °C above the maximum conductor temperature of the cable in normal operation, as given in the relevant standard for extruded insulation cables.

It is considered that stabilization has been reached, if the conductor temperatures, $a_1$ and $a_2$, do not show any variation larger than 2°C within a 2 h period.

When stabilization has been reached, the following should be noted:

a) Conductor temperature, $\theta_{cond} = (a_1 + a_2)/2$
b) Sheath temperature, $\theta_{sheath.c} = (b_1 + b_2)/2$
c) Ambient temperature, $\theta_{amb.c}$
d) Heating current, $I_{cal}$

## A-3 HEATING FOR ACCESSORY TEST

Let

$R_{20}$ = resistance per unit length of conductor at 20°C (*see* IS 8130);

$\alpha_{20}$ = temperature coefficient of resistance at 20°C (*see* IS 8130);

$T$ = thermal resistance between the conductor and the surrounding medium (including $T_4$, the thermal resistance of air); and

$T'$ = thermal resistance between the conductor and the external surface of the cable (excluding $T_4$, the thermal resistance of air).

NOTE — $T' = T_1 + nT_2 + nT_3$ where $n = 1$ for single core cables; $n = 3$ for three core cables and $T = T' + n\,T_4$

$\theta_{amb.t}$ = ambient temperature during accessory test;

$\theta_{sheath.t}$ = temperature of external surface during accessory test; and

$I_{test}$ = current during accessory test.

### A-3.1 Method 1: Test Based on Measurement of Ambient Temperature

Assuming that dielectric, metallic sheath and armour losses are negligible,

a) During cable calibration:

$$\theta_{cond} - \theta_{amb.c} = R_{20} * I^2_{cal}\,[1 + \alpha_{20}(\theta_{cond} - 20)]T \qquad \ldots(1)$$

b) During accessory test:

$$\theta_{cond} - \theta_{amb.t} = R_{20} * I^2_{test}\,[1 + \alpha_{20}(\theta_{cond} - 20)]T \qquad \ldots(2)$$

(It is assumed that $T$, and particularly $T_4$ has not changed).

Combining (1) and (2) gives:

$$I_{test} = I_{cal}\sqrt{\{(\theta_{cond} - \theta_{amb.t})/(\theta_{cond} - \theta_{amb.c})\}} \qquad \ldots(3)$$

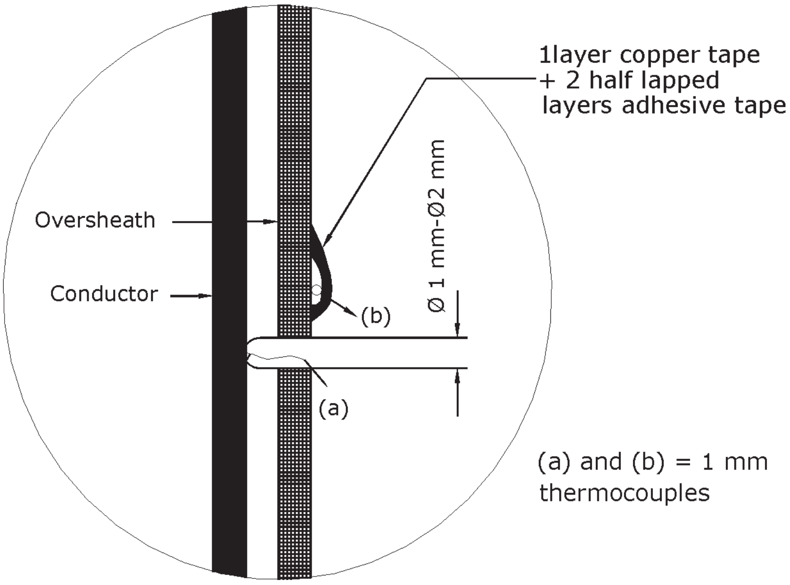


FIG. 12 ARRANGEMENT OF THE THERMOCOUPLES

### A-3.2 Method 2: Test Based on Measurement of the External Surface Temperature

a) During cable calibration:

$$\theta_{cond} - \theta_{sheath.c} = R_{20} * I^2_{cal}\,[1 + \alpha_{20}(\theta_{cond} - 20)]T' \qquad \ldots(4)$$

b) During accessory test:

$$\theta_{cond} - \theta_{sheath.t} = R_{20} * I^2_{test}\,[1 + \alpha_{20}(\theta_{cond} - 20)]T' \qquad \ldots(5)$$

Combining (4) and (5) gives:

$$I_{test} = I_{cal} \sqrt{\{(\theta_{cond} - \theta_{sheath.t})/(\theta_{cond} - \theta_{sheath.c})\}} \qquad \ldots(6)$$

It should be noted that equation (4) allows the determination of the internal thermal resistance *T'* of the cable from readings of temperature and current.

Equation (5) can be written in the form:

$$\theta_{cond} = [\theta_{sheath.t} + (1 - 20\alpha_{20})\, R_{20}\, I^2_{test}\, T'] \,/\, [1 - \alpha_{20}\, R_{20}\, I^2_{test}\, T'] \qquad \ldots(7)$$

It is therefore possible to transpose this formula in the form of chart, as shown in Fig. 13, giving $\theta_{cond}$ from $\theta_{sheath.t}$ readings, for various values of the heating current $I_{test1}$, $I_{test2}$, ………….

The use of such a chart is advisable, if the test is not automatically controlled.

### A-3.3 Method 3: Test Using a Control Cable

In this method, a control cable identical to the cable used for the test is heated with the same current as the test loop. The cable is not energized and therefore thermocouples can be fitted to the conductor as recommended in **A-2.1**.

The test arrangement should be such that,

a) the control cable should carry the same current as the test loop at any time, and

b) it should be installed in such a way that mutual heating effects are taken into account throughout the test.

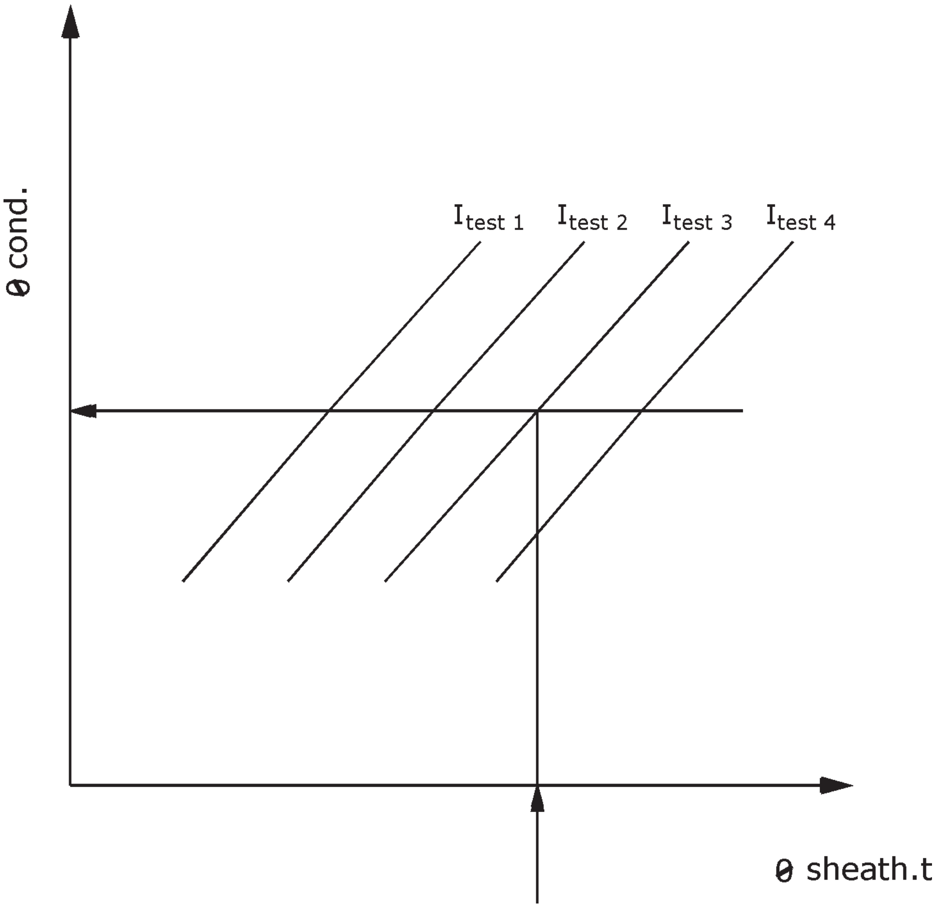


FIG. 13 CURRENT/TEMPERATURES CURVES

The thermocouples should be mounted on the external surface of the test loop at the positions given in Fig. 11, in the same way as the thermocouples are mounted on or under the surface of the control cable.

The temperature measured with the thermocouple fitted to the conductor of the control loop may be considered as representative for the conductor temperature of the energized test loop.

All thermocouples should be connected to a temperature recorder to enable temperature monitoring. The heating current of each test loop should be recorded to prove that the two currents are of the same value throughout the duration of the test. The difference between the heating currents should be kept within ±1 percent.

The heating current is adjusted so that the conductor temperature is kept within the specified limits.

NOTE — The temperature measured with the thermocouples on the oversheath of the energized test loop and of the control cable, are used to check whether the oversheath of both test loops has the same temperature.

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### Amendments Issued Since Publication

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